Nuclear Energy in This Century – A Bird in the Hand

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Abstract

This presentation reviews the past half-century of nuclear energy from one person's point of view, fully recognizing likely errors in fact and perception. It also takes a look at the coming 50 years of our enterprise. The future will demand a lot from nuclear technology, given the decline in the availability of cheap fossil fuels and the expected rising need for energy. We can supply safe and reliable energy for thousands of years, if such is necessary. Uncertainty remains in the short term regarding the support of the people and of the governments who serve them.

1. Introduction

My surprise at being asked to present this lecture soon gave way to concern about finding something useful to say on this occasion. So, I looked back to the papers written by two distinguished lecturers in this series dedicated to the memory of Dr. W. Bennett Lewis. There I found my answer. In June 2008 Dr. John Cowan, then principal of the Royal Military College of Canada, made a strong case for a truly liberal education as the necessary basis for the growth and maturing of a modern military officer. In 2009, Dr. David Torgerson, Emeritus Senior Technology Officer at AECL, presented an excellent description of some of the scientific opportunities ahead of us in the future of this great world energy enterprise.

At the end of my 50-plus years working in the nuclear industry, mostly as an engineer, it may be useful to review the past half-century of our progress as a possible guide to the future. Underlying this choice is my firm belief that three components are essential to our future success; namely, science, engineering, and sociology – this last in the broadest sense of that term.

Before going further I would like to mention a new award in Dr. Lewis' honor, established by the American Nuclear Society in 2006. The accompanying citation reads: "This award recognizes persons who have made major lifetime contributions in nuclear science and engineering toward minimizing the environmental footprint, attaining long-term global sustainable energy and development, and having shown great foresight in elucidating these goals." Dr. Lewis worked toward sustainable energy long before this term was invented. (This year's recipient of the award will be Dr. Georges Vendryes, a French pioneer in fast reactor research and development.

To recognize the sterling achievements of Dr. Lewis and all of the thousands of able scientists, engineers, and technologists who created the system, the last part of my title "A BIRD IN THE HAND" is symbolic of existing CANDU power plants. Whatever else happens, Canadians can be justly proud of the CANDU and all that it can do. Is it perfect? Of course not, but is it better than 48 out of 50 other design concepts? Yes, it is. Is it just as good as the other two modern reactor types that have reached commercial maturity? You bet!

As for the first part of the title, "NUCLEAR ENERGY IN THIS CENTURY", the phrase is meant to convey immediacy, and a real sense of urgency. Fatih Birol, chief economist of the International Energy Agency of the OECD, strongly reminds its member nations:

> "One day we will run out of oil, it is not today or tomorrow, but one day we will run out of oil and we have to leave oil before oil leaves us, and we have to prepare ourselves for that day. The earlier we start, the better, because all of our economic and social system is based on oil, so to change from that will take a lot of time and a lot of money and we should take this issue very seriously".

At the same time the world can take comfort in the fact that there is enough nuclear fuel available to supply us with energy for thousands of years. Once again we are fortunate to have "A bird in the hand" in the form of nuclear technology. Our descendants may well invent a better way to meet this need – but just in case they do not, we know that nuclear fission energy can do the job. I expect that a diverse suite of alternative sources will persist over time in niche markets, but that nuclear energy will provide the bulk of the world's supply for a very long time. We must do the heavy lifting!

Many of us have spent decades working in the nuclear industry. Most of our time has been spent with our figurative noses to the grindstone, working away at this or that technical task. By and large we have done our jobs with enthusiasm – and our efforts have been blessed with a good measure of success. What we did not always carefully note was a dark cloud of suspicion of our venture that built up in the community around us, fostered skillfully by radicals of various sorts and motivations. I will come back to this subject a bit later on.

2. The Need

Of course, it would be pointless to be doing any of this work if there were no need for the product, electrical energy. In making this statement I draw a fine line of distinction between science and engineering. In the former case a lack of apparent need is irrelevant to the question of whether or not to follow a certain line of investigation. In contrast, the professional practice of engineering exists solely to satisfy the needs of at least some part of society. The engineer's task in this case is to provide energy to the world; national boundaries mean nothing to this responsibility. It is a global task.

The world is entering a major energy transition. Oil prices are fluctuating on international markets as costs of production increase and as producing countries restrict exports to retain domestic supplies within their own economy. The modern hypothesis of man-made global warming results in worldwide concern about the use of all fossil fuels. At the same time, especially in developing countries, the need for oil is increasing as economies expand. (The recent world recession has put a kink into this growth pattern, but it now seems to be ending.) Apparently, we need a new primary energy resource that can be utilized on a scale comparable to that of oil. It is obvious as well that this new resource must be safe, reliable, and must not cause substantive damage to the earth's environment.

Each year the International Energy Agency of the OECD publishes a report titled "World Energy Outlook" [1]. The latest issue of their report presents a sobering picture in their reference scenario, which follows the expected trajectory of world energy development over the next 20 years, assuming that world governments make no changes to their existing policies and measures for energy supply. This scenario is dominated by large increases in demand for fossil fuels, extensive exploration, and consequent large capital requirements. The expected total investment requirement is 26 trillion dollars up to 2030. The power sector requires 53% of this total. Reference 1 concludes that:

> **"Continuing on today's energy path, without any change in government policy, would mean rapidly increasing dependence on fossil fuels, with alarming consequences for climate change and energy security."**

For the past several years the IEA has urged OECD governments to increase their commitment to nuclear energy. Most countries of the world show signs of taking up this challenge, with the surprising exception of the OECD countries themselves. In both Europe and North America the response is half-hearted at best, up to now. The IEA report notes the following:

> "The main driver of demand for coal and gas is the inexorable growth in energy needs for power generation. World electricity demand is projected to grow at an annual rate of 2.5% to 2030. Over 80% of the growth takes place in non-OECD countries. Globally, additions to power-generation capacity total 4,800 gigawatts by 2030 – almost five times the existing capacity of the United States. The largest additions (around 28% of the total) occur in China. Coal remains the backbone fuel of the power sector, its share of the global generation mix rising by three percentage points to 44% in 2030. Nuclear power grows in all major regions ***bar Europe***, but its share in total generation falls."

The underlying driver of this demand growth usually is, of course, the rise in world population – energy demand growth is a consequence of this seemingly uncontrollable factor. At the present time, however, it seems that much growth arises from the need (or at least the desire) of underdeveloped countries to increase their standard of living. Any energy policy must be coupled with stabilization of the world population along with raising of living standards. A sustainable level of energy supply is a necessary prerequisite if we are to provide a respectable living standard for all people.

3. Meeting the Need

In its 2009-2030 alternative (preferred) scenario, called the "450 Scenario" to highlight a target of 450 parts per million concentration of carbon dioxide in the atmosphere, the IEA points out that

> "Power generation accounts for more than two-thirds of the savings (of which 40% results from lower electricity demand). There is a big shift in the mix of fuels and technologies: coal-based generation is reduced by half, compared with the Reference Scenario in 2030, while nuclear power and [*other*] renewable energy sources make much bigger contributions."

Three points are notable in this statement. First, I have inserted the word "other" in square brackets to emphasize the now-recognized fact that nuclear fuels are inexhaustible within the expected duration of human life on earth, and so this energy source must be included in the "renewable" category. Second, the hoped-for amount of demand reduction due to conservation in the electricity sector is very large – a most optimistic projection, given past performance. The third item of note is the imminent approach of the year 2030. There is very little time left for our world to adapt to the coming collapse of the present-day climate in which petroleum is relatively plentiful and cheap. It is quite apparent that someone must repay the tens of trillions of dollars that must be invested in oil supply development to ensure supply of oil up to 2030. It also leaves a big question as to what we might expect to happen during the <u>following</u> quarter-century. For a rather gloomy guesstimate of the upcoming situation, see the apocalyptic prediction in the book "The Long Emergency", by James Howard Kunstler [2].

Accepting the IEA estimate of "new build" generation capacity requirements up to 2030, and then assuming that all these new plants will be powered by uranium, we will need to build 240 nuclear units each of capacity 1 gigawatt every year between now and 2030. This <u>ideal</u> situation will not be realized, of course, but the number certainly provides a "stretch" target for new nuclear plant construction. Once again, with reference to the IEA alternative scenario, there is another challenge implied – the provision of transportation fuels. This additional challenge is addressed in the next section of this paper.

Where else could we get this massive energy supply? Dr. Charles Till, retired Deputy Director of Argonne National Laboratory [3] reaches the following conclusion:

> "To sum up, the alternatives to fossil fuels that could promise the magnitudes of energy required to meet our nation's need are very, very few. It is not as though plentiful alternatives exist, and one can be weighed against another … "
>
> "The blunt fact is that there are the fossil fuels and there is nuclear."
>
> "Failure to recognize this, while focusing on options that do not and cannot have the magnitudes [of supply] required, will inevitably lead to increasingly dangerous energy shortages. Who then will answer? Will [it be] the environmental activist, who blocks real options, and then puts forth options that cannot meet the need?"

Who else indeed? Will it be the politician who is ready to subsidize unsustainable short-term solutions and who forever plans for his re-election, carefully deferring difficult decisions until after that happy day? Not likely.

My conclusion is that the engineer will answer, based on past history. More generally, it is the organization that people really expect to deliver the goods – usually the electrical utility or other operating organization. Because of the long time scale of these decisions and their consequent good or bad impact on society, the politicians get away with no need to answer to anyone. As

Rudyard Kipling wrote, the Sons of Martha must answer the people, and the Sons of Mary go free. [4].

Nuclear energy is similar to both the oil industry and coal industry, in terms of the time scale involved. Exploration, development and market delivery times are much longer than political cycles. Only real statesmen can and do listen to recommendations whose consequences lie further in the future than the next round of the election cycle.

4, The Problem of Scale

In the study of energy supply, both resource magnitude and achievable rate of extraction must be considered. For example, the sun provides us with a huge amount of energy, but this energy is spread over the whole earth and it oscillates down to zero daily. We should, of course, be very grateful to the sun for what it does well – it sustains the earth's temperature at a level 300 degrees higher than surrounding space. Without it we would not exist.

Figure 1 shows all of our primary energy options. Among the options that are concentrated and thereby easily collected, by far the largest energy potential is from coal or uranium. Figure 2 compares nuclear and coal (this Figure is a summary of a summary taken from a larger work in process of publication, with permission of the authors.) Wind is included here to show the best of the diffuse options – and the most popular today. Its primary disadvantage is its highly variable nature, which must be compensated for by either backup sources or by major energy storage facilities.

Coal suffers from an extraction rate limit as well as uneven distribution of deposits – thereby causing transportation difficulty in some areas. Nuclear fission energy is the clear choice. Nuclear energy is concentrated and so has only minor transportation problems for either fresh fuel or for used fuel. In addition, this fuel is inexhaustible [5].

Figure 3 illustrates the very large quantities of fuel available from nuclear energy. Using today's technology (thermal reactors) along with the 2005 total world energy usage, we see that at least 40 years of fuel supply are assured. Assuming a reasonable rate of exploration and tolerable increases in fuel price, at least 300 years of fuel supply most likely is available from only uranium. Accounting for thorium fuel supply probably would double the amount shown here.

Fast reactors apparently are necessary to extend nuclear fuel availability in time, to well beyond the horizon of human existence. It is not practical to mine uranium from seawater to fuel thermal reactors, because of the very large required extraction rate. Fast reactors do not suffer from this drawback, however, because a one-gigawatt electric unit requires only 2 tons of makeup uranium per year. This makeup fuel also can be obtained from dilute ore deposits, from the ocean, or from depleted uranium from enrichment plants. This huge diversity of fuel sources arises because of the very large amount of potential energy in each unit of natural uranium or thorium,

Figure 1 – Energy Options

Source	What's Available?	How Much?
Oil Natural Gas Coal Geothermal	Derived from stored solar energy plus the decay of radioactive materials in the earth. Half of available oil has already been used	0.4 yotta (10^{24}) Joules Coal is the largest source
Hydro Wind Solar Tidal Biomass	Derived from direct solar (fusion) or from earth's and moon's kinetic energy. Diffuse and limited in either total capacity or achievable extraction rate.	3.8 yotta (10^{24}) Joules per year Approximately the same amount of energy is radiated to space per year
Uranium Thorium	Derived from the explosion of a supernova, some 6.5 billion years ago. Inexhaustible total capacity and widespread availability. High potential extraction rate.	>320 yotta Joules Uranium in seawater is the largest source

Figure 2 - Resources Consumed per Gigawatt of Production Capacity

Type of power plant	**No. of units, land area**	**Fuel Required per year**	**Solid Waste tons/year**	**Gaseous Waste, incl. GHGs**	**Avail-ability (%)**	**Cost US$ /MWh**	**Life-time (yrs)**
Nuclear (LWR)	**One or two units, small area**	**20 tons uranium dioxide**	**1 ton fission products in ~15 tons HLW**	**No CO_2 or other GHGs during operation**	**~ 90**	**45 - 120**	**>60**
Coal	**One or two units, small area**	**~ 4 million metric tons of coal**	**~ 0.4 million tons of ash**	**~ 13 million metric tons of CO_2**	**~ 80**	**30- 90**	**~ 30**
Wind	**5,000 units, 1 Mwe each (area 450 km^2)**	**~ 1.6 x 10^9 m^3 nat. gas (backup)**	**Depends on type of backup power**	**Depends on type of backup power**	**20-35**	**120 - 220**	**~15**

Figure 3 - NUCLEAR FUEL QUANTITIES POTENTIALLY AVAILABLE FOR USE

Sources of Uranium and Thorium		Resources (thousands of tonnes)	Exajoules (Thermal Reactors)	Exajoules (Fast Reactors)
U	WNN, 2008	5,500	2750	437,000
U	[Metz, 2000]	15,400	7700	1,223,000
U	Used Fuel	2,000	-	160,000
U+Pu	Surplus Military	Small	-	Small
U	Phosphate Deposits	20,000	10,000	1,600,000
U	Dissolved in Seawater	4,400,000	-	317,800,000
Th	[IAEA TECDOC 412]	1,160 (low?)	600	95,300

NOTE: World Primary Energy Use in 2005: 457 Exajoules

5. The Challenge

It may seem that the biggest challenge facing today's nuclear industry is the task of building more than 200 large nuclear units per year. This task certainly is large and filled with questions such as finding appropriate building sites for all those plants, acquiring all the steel, cement and other commodities necessary to get the job done, and many other items – to say nothing of accumulating all the capital necessary to get the job done. But the world nuclear industry has, after all, done this once already from a standing start with an inventory of zero commercial plants existing in the beginning. We now have three mature power plant concepts (PWR, BWR, PHWR), plus a fourth (the FBR) that is ready to meet the long-term challenge. Perhaps more importantly, having built a few dozen prototypes of different design, we now should know what does NOT work. It is important to study and remember these lessons.

Today we have the lessons of nearly five hundred operating commercial stations to back us up. We have greatly improved knowledge of the technology as well as excellent computer models of the hardware and the processes involved. We have a large group of people well versed in all the essential steps from research to waste disposal.

One of the largest technical tasks ahead of us is to reduce the volume of hydrocarbons required for transportation. Either gasoline and diesel must be replaced by electricity or hydrogen [6] or synthetic hydrocarbons must be produced. This will require an increase in nuclear capacity. North American cities in particular require people to drive personal automobiles. Plug-in hybrid or electric cars and electricity will be needed offset today's demand for gasoline and natural gas.

In these hundreds of ‘new build’ nuclear projects we see a challenge that is almost completely one of scale. This is not an R&D task. This is nation building - pure, but not so simple. We have all the tools in hand. If we cannot do this job correctly we must look to fundamental causes other than the technology, and correct them – fast. There is little time remaining.

The most immediate and pressing challenge lies in the field of government support and, at a broader level, in the issue of public acceptance. This is so in spite of nuclear energy enjoying the support of 60 to 80 percent of the general public. A vocal minority of opponents command disproportionate influence over the actions of our governments. The result is continuing delay, cost escalation, and resultant uncertainty facing any “real” project proposal. We should ignore the many superficial proposals to ‘do more R&D’, on sometimes far-out possibilities – these proposals serve only to add to the delay in facing the immediate challenge. We can better address the challenge by first recognizing a few expectations about our future:

- Coal will meet a large portion of electrical demand, albeit at increasing social cost
- Oil prices will increase in response to demand, thus forcing fuel switching
- Many different energy systems will be tried. Some will succeed; others will fail
- Fission reactors of existing design will power most new plants for the next 50 years
- Development of fast breeder reactors will continue in a few countries
- Cost control and high cost certainty will continue to be vital to success
- People will not easily give up their modern creature comforts

The Canadian government recently proposed a new policy [7] that would see the phase-out of all coal-fired generation within the next twenty years, to be replaced with low-emission alternatives. Natural gas is identified as the leading alternative, but this dream is very unlikely to be realized due to a continental shortage of gas supplies (in spite of the ‘shale gas’ bubble.) Nuclear energy can meet this challenge – the CANDU reactor design is ready and able to replace coal-fired generation.

6. The Way Forward

The future is ‘uncomputable’ according to David Orrell, author of the book Appolo’s Arrow, The Science of Prediction and the Future of Everything [8]. We can, however, construct a set of scenarios that illustrate our society’s preferences for future development of humanity. Then, we can take actions that tend to point us in the desired direction even in the face of major uncertainties. We may even be so fortunate as to reach a future that is tolerable.

Two defensive concepts have been formulated to deal with uncertainty [9,10]. The first is the well-known concept of “Defence in Depth”. In the case of energy supply, this concept can be expressed in terms of the objective of diversity; that is, we should develop diverse energy technologies, each of which offers at least a partial solution to the problem. Winston Churchill applied this idea in his plan for conversion of the Royal Navy from coal firing to oil firing. Its modern equivalent is the “wedge” theory of Socolow, as applied to the climate problem [11]. We have an advantage relative to the Royal Navy's problem; they had no indigenous oil reserves but we hold an essentially infinite reserve of uranium inside our borders.

The second defensive concept can be identified as "Defence in Time". In the context of energy supply, this concept can be expressed in terms of the objective of preparedness; that is, at any given time we should be prepared to take timely action to adapt our energy supplies to changed circumstances. In order to be prepared, we must keep watch on apparent changes such as availability, price, and needs. We also must extrapolate at least 50 years into the future (because adaptation of new energy systems is slow) and take early action so that, when the need arises, we will be prepared to respond.

Today, industry involved in the delivery of uranium-fuelled power plants is in a fairly good position in spite of the recent drastic 30-year slowdown in orders for new plants caused by an organized anti-nuclear-energy minority, supported in some cases by national governments. Performance of existing plants has steadily improved as staff and equipment have evolved. These plants now may be considered to embody a mature technology. Recent new orders are stimulating a revival in design, manufacturing and construction capability. There are more than 52 large units under construction around the world, with about 140 on order or planned, and a further 340 proposed. The advent of detailed computer-aided drafting, design, and construction systems has overcome earlier problems arising from plant complexity. Design and construction is, in effect, now done first in the office (on a computer) before fieldwork begins. This change, plus a revolution in construction involving prefabricated sub-assemblies and "top-in" installation have enabled a revolution in plant construction [12].

In some countries, most notably in the United States, long-term fuel waste management has developed into a major political issue. Facts and practical realities seem to be of secondary importance in these arguments; the resulting impasse has dramatically slowed the promised renaissance of the industry in that country. The apparent high cost of "new build" plants in the US is acting as a powerful deterrent, as are various state-based negative initiatives. Price has been artificially increased by uncontrollable uncertainty factors. In at least one case in Canada, extreme demands in the RFP to accept all risk over the life of the plant have led to apparent cost increases as contingency allowances were applied to the bids.

At the same time, the rising cost and limited supply of commercial crude oil supplies promises to override the mainly political objections to expanding the application of nuclear energy. Coal and nuclear energy can combine, through nuclear-hydrogen-based liquefaction processes, to solve at least part of the transportation fuel requirement.

Where should we go from here? The need is great and the time is short.

Future development of this technology is constrained by several factors. The most important of these, which will be applied to each new unit of capacity, are:

- The plant, when proposed, must have a suitable site and associated facilities.
- The plant, when delivered, must be capable of reliable and safe operation for at least a half-century. Otherwise, the user will not purchase it.

- The plant must be cost-competitive with existing mature units. Otherwise, it will not be purchased.
- The plant must have a lifetime fuel supply, or at least a well-founded expectation of such.
- The plant must have a full complement of trained staff and a plan for continued staff replacement over a period of 50 years or more (several generations of engineers)
- The plant must have an achievable plan for waste storage.
- Society must accept the technical conclusion that a suitable method for disposal of long-lived radioactive materials exists, and work steadily toward that goal [13].

These factors are, today, quite different than the ones that existed during the first major building program of commercial uranium power plants some years ago. During that early period, new prototype and first-of-a-kind commercial plants were purchased very much “on faith”. Development subsidies were the order of the day. That is not likely to happen again.

Government policy could provide a sound pathway for introduction of innovative new generation technologies [14]. However, given the broad demand for government subsidies by a wide variety of other proposed programs, long-term development funding cannot be expected by the nuclear industry – the electricity production business already is a large and mature industrial venture. This fact brings nuclear technology back to the customer as the main supporter for new generation. The needs of the customer will be paramount in any future decisions for new uranium-fuelled generating capacity. The rest of the industry must adapt to these needs. A major opportunity, on the other hand, lies in application of nuclear energy to satisfy energy needs outside of the delivery of electricity. Gurbin and Talbot [16] presented some of the possibilities in a 1994 paper.

Figure 4 - Bruce Site Today (a prototype for future)
6000 Mwe Electricity Production Capacity from CANDU

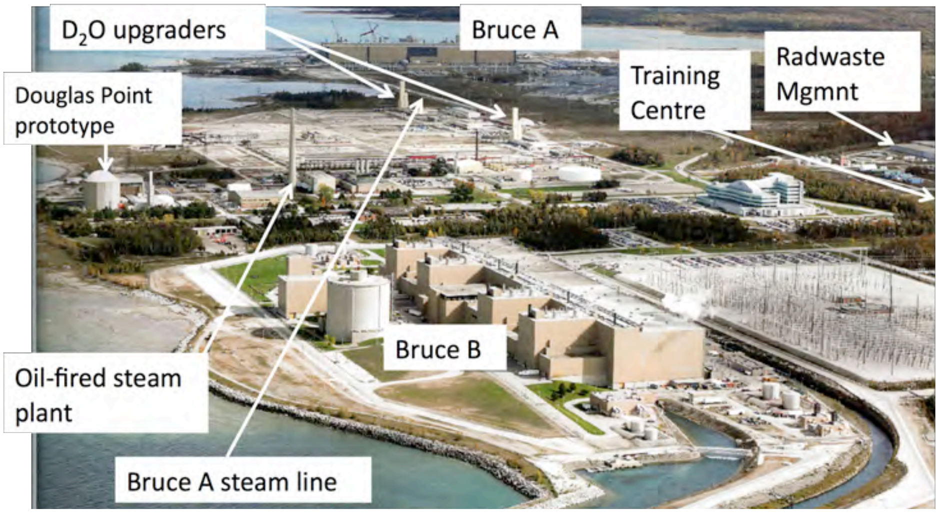

Figure 4 shows the Bruce site adjacent to the Bruce Energy Centre. It offers a good base for future development that could lead to a future industrial complex somewhat equivalent to a major oil field surrounded by industries using its product for various purposes.

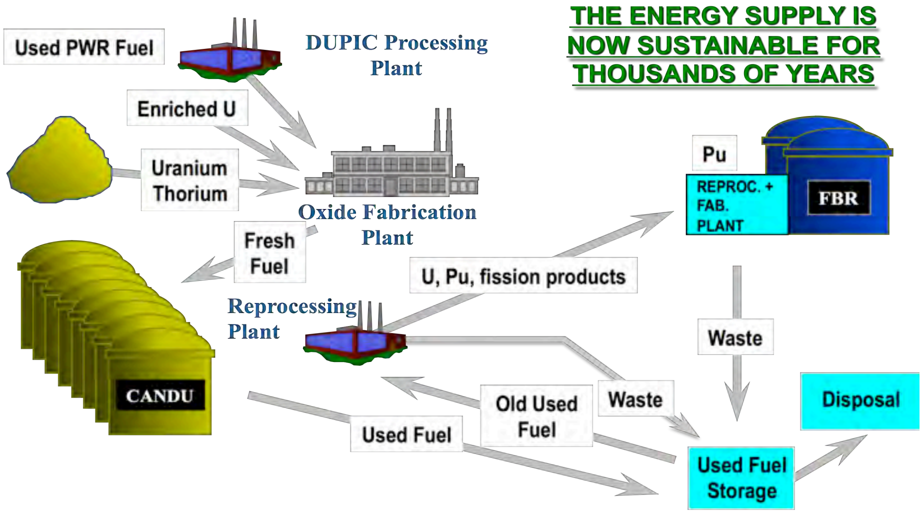
Figure 5 -- A CANADIAN DREAM

Figure 5 indicates one possible long-term development [16] of the Bruce site. Such sites, located around the world, could provide – along with small satellite reactor sites – a sustainable energy supply for thousands of years.

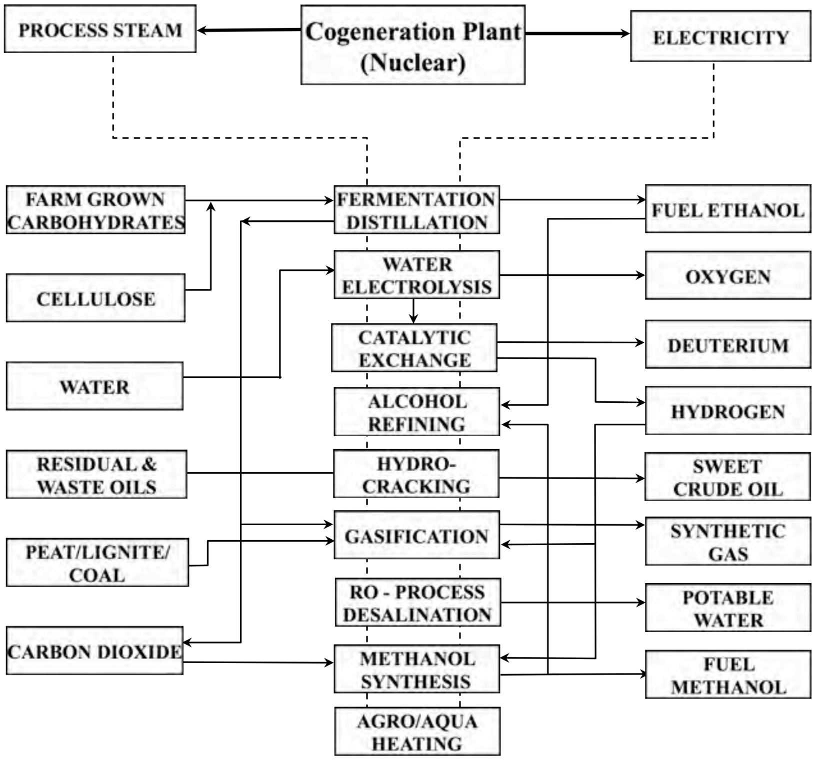

Figure 6 – Potential ladder of industrial processes at BNPD [15]

Figure 6 shows the "energy cascade" proposed by Gurbin and Talbot. Their ideas were scheduled for implementation at the Bruce Energy Centre, but the project was cut short. The concept was scrapped when British Energy, the company that leased the site from Ontario Hydro (now OPG) rejected the idea of using excess steam from Bruce A to provide steam to the energy centre.

Figure 6 includes a variety of applications beyond the production of electricity. The list is not exhaustive, nor is it guaranteed that all of these possibilities could be realized economically.

7. Financing

Financing is difficult for large projects such as nuclear plants. Two good comparisons are seen in development of a new oil field and the construction of a continental highway network. In the first case large capital resources must be committed many years before any return can be expected. In the second case, people expect that taxpayers will fund major highway construction.

Bill Gates [14] puts forward a precise and simple explanation of the problems of nuclear plant finance. He argues that the private sector will remain unable to finance this new build program, but that governments can help a great deal. The US government has, in fact, begun this process by offering loan guarantees. A similar system was utilized to finance construction of the Qinshan-3 project in China; nations associated with several major systems and components used export development loans of various kinds. This operation was very successful, and the loans are now being paid back expeditiously.

Financing of a nuclear plant to be built in Canada would appear to be even easier. Government loan guarantees could be established in support of the project. Loans would be repaid over time during plant operation. Financing also would be greatly eased if some of the capital expenditures incurred during plant construction could be charged into the rate base, recognizing that plant benefits will eventually accrue largely to those same ratepayers. Both of these alternatives depend completely on the support of the community where the plant is located, thus underlying the paramount importance of their trust that the plant being constructed is truly in their interest. Of course, this is a political and sociological question.

The complexity and uniqueness of project arrangements for building a large plant defeat any attempt to generalize the process. There is no doubt that it is one of the crucial steps toward success. Expert management combined with careful project planning, clear definition of roles and goals, along with comprehensive design and scheduling of each step of the project can lead to timely and economical project completion [12].

8. The Customer

The customer is sometimes forgotten in the multi-year design and organization process that must be completed before the actual project begins. It is vital for project management to know the customer and to understand the specifics of the buyer's capabilities, needs, and limitations. Even an "ideal" plant design may not match these basic requirements, and so will fail.

Given this situation it seems obvious that the most productive path forward for new generating plants is one of slow design evolution, with new designs firmly anchored in the technology and operating experience of existing successful power plants. The utility customer must, after all, be willing to accept each "improvement"; otherwise, it will not be incorporated in the plant.

One of the paramount needs of the plant customer today is a predictable policy for medium term used fuel storage, and a sound plan for long term waste management. The customer must take the initiative; as the waste producer it is the customer's basic responsibility to push forward these waste management plans. In Canada, this task is in the hands of the Nuclear Waste Management Organization, led by the nuclear utilities.

9. The Community

The customer lives and works within the larger community served by the plant. Without the support of the community, any project of this large scale simply cannot succeed. Vocal, minority opposition that has dogged the industry for many years seems now to be decreasing, but it easily could increase again if and when some problem arises in the industry.

In one sense this opposition is useful – it keeps us on our toes. At the same time the common sort of opposition requires a large amount of effort to repeatedly refute the spurious claims of those who are dedicated – some say religiously dedicated – to opposing any activity associated with the adjective "nuclear". The distribution of these zealots is wide. Some can be found embedded in governments and other respected institutions, at times very near to the top levels.

Do we have any "respected institutions" remaining in our society? Hugh Heclo [17], in his book "On Thinking Institutionally" asks us to re-examine our opinions of those institutions on which we rely so heavily, and yet for which we show very little respect. At times, of course, institutions go off the rails and no longer deserve respect – Heclo addresses this phenomenon as well. He illustrates the situation with many examples, and points out that the systematic denigration of our basic institutions has been building up over the past century, to the point that it is now hardly appropriate to support many of them when speaking in polite company.

It must be obvious that our society cannot function without a large number of institutionalized organizations and processes. It is equally obvious that these institutions must earn and hold the respect to the general population. In the case of an operating nuclear utility, this generates a powerful need to <u>deserve</u> the trust of the people from day to day. The same applies to all aspects of our industry, and more so because the integrity of this institution is always under challenge.

"Deserving of trust" is, of course, in the eye of the beholder. Today's political climate of challenge to all institutional authority, coupled with our new instant and worldwide communications pathways, makes it very easy to generate dissent on virtually any topic. The virtue of truth-telling, and the normal penalties for violating that norm, have decreased in recent years. Herein the root cause of our public relations trouble. Perfectly rational people who have a deep understanding of the nuclear industry criticize the industry for not "standing up" to the onslaught, and presenting the true story. An excellent example can be found at Ted Rockwell's blogsite, < http://www.learningaboutenergy.com/>. We must do whatever we can to eliminate the falsehoods, the distortions, and the extreme assumptions from our technical discussions.

Over the years of verbal conflict between scientists and engineers versus their opponents, the "defensive ramparts of truth" have become bent and battered to some degree. This is especially so in the area of nuclear regulation, where the technical arguments of the proponents meet the political reality of the day, in which the regulator must defend any decisions to allow a project to proceed with a very high degree of assurance. That institution also is challenged every day, the same as all the rest.

In order to continue this great enterprise of providing the world with plentiful energy, we must remember always to defend the “ramparts of truth” and to rebuild them as and when necessary.

11. Conclusion

Nuclear fission energy is ready and able to provide the world supply of energy for thousands of years. There is a need for this energy to reduce and, in many cases, to eliminate the use of fossil fuels. The need to engage in building facilities to accomplish this huge task is an urgent one; there are clear signs that petroleum supplies are not sustainable at the rate that we are now extracting them, and equally clear signs that coal cannot do the whole job due to atmospheric pollution considerations. Reluctance to proceed with building new is apparent in some countries, while other countries are going ahead energetically, some building several units in parallel. The wisdom of each choice will be revealed within the coming decades.

10. References

[1] International Nuclear Energy Agency, "World Energy Outlook, Executive Summary" (2009)

[2] James Howard Kunstler, "The Long Emergency: Surviving the End of the Oil, Climate Change and Other Converging Catastrophes of the Twenty-First Century", Grove/Atlantic, (2006), ISBN-13: 9780802142498

[3] Charles E. Till, "Plentiful Energy, The IFR Story, and Related Matters", The Republic News and Issues Magazine, Jun-Sep 2005.

[4] Rudyard Kipling, from "The Ritual Calling of an Engineer"

[5] H. Douglas Lightfoot et al., "Nuclear Fission Fuel is Inexhaustible", Proceedings of the EIC Climate Change Technology Conference, Ottawa, (2006)

[6] David S. Scott, "Smelling Land: The Hydrogen Defense Against Climate Catastrophe", Canadian Hydrogen Association, (2007), ISBN 978-11-896881-73-7

[7] Shawn McCarthy, "Ottawa tells energy firms to start powering down coal-fired plants", Globe and Mail, Apr. 25, 2010

[8] David Orrell, "Apollo's Arrow: The Science of Prediction and the Future of Everything", Harper-Collins, (2007), ISBN 0002007401

[9] Karl E. Weick, Kathleen M. Sutcliffe, "Managing the Unexpected: Resilient Performance in an Age of Uncertainty", 2nd Edition, Jossey-Bass, (2007), ISBN 978-0-7879-9649-9

[10] Romney B. Duffey, John W. Saull, Know the Risk: Learning from Errors and Accidents: Safety and Risk in Today's Technology", Elsevier, (2002), ISBN-13: 9780750675963

[11] S. Pacala and R. Socolow, "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies", *Science* (13 Aug 2004), Vol. 305, no. 5686, pp. 968 – 972

[12] K. Petrunik & K. Rixin, "Qinshan CANDU Project Construction Experiences and Lessons Learned to Reduce Capital Costs and Schedule Based on Qinshan CANDU Project in China", Proc. 24th Canadian Nuclear Society Annual Conference, (2003)

[13] Nuclear Waste Management Organization, "Implementation Begins", URL: < http://www.nwmo.ca/Default.aspx?DN=3a4a4e2e-1102-4e13-87c2-6cc0e34aefc4>

[14] Bill Gates and Chad Holliday, "Energy sector poised for innovation -- with the right spark", Washington Post, Friday, April 23, 2010; A19

[15] G. H. Gurbin and K. H. Talbot, "Nuclear Hydrogen - Cogeneration and the Transitional Pathway to Sustainable Development", Proc. PBNC9, (1994)

[16] D.A. Meneley, "Large Scale Extraction of Uranium Energy", Proceedings of Nuclear Symposium, Canadian Institute, Saskatoon, Sask., March 23, 2010

[17] Hugh Heclo, "On Thinking Institutionally", Paradigm Publishers, Aug 2008, ISBN - 10:159451296